OBSERVATIONS ON A LARGE POPULATION OF THE VULNERABLE PYGOPODID, *DELMA TORQUATA*.

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The pygopodid, *Delma torquata*, is listed by ANZECC (1991) as vulnerable. The current study shows that, despite the paucity of previous records, the species can be relatively abundant at localities of suitable, undisturbed habitat. The density of this population appears to differ markedly from that observed for other *Delma* spp. Field data indicate that this species is a diurnal, thigmothermic, insectivore whose occurrence suggests a preference for rocks of slightly larger than average size, situated amongst sparsely vegetated areas. Juveniles attain a snout-vent length of 32mm by their first winter. This size is doubled by the third winter. The species' apparent sensitivity to minor habitat disturbance or alteration may be a contributing factor to its scarcity and patchy distribution. □ *Pygopodidae, Delma torquata, vulnerable, population study, southeast Queensland.*

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To date, *Delma torquata* Kluge, 1974 is restricted to 13 scattered localities in SE Queensland (Kluge, 1974; Ingram & Raven, 1991; Queensland Museum records). It is currently listed as vulnerable (ANZECC, 1991). A contributing factor, to this status is that much of its distribution coincides with areas of high human population and impact (Czechura & Covacevich, 1985). This apparent rarity is also reflected by the small number of specimens currently held in Australian museums (Queensland Museum, [13] QMJ5683, 9285, 14365, 21220, 21667, 22026, 25997, 27520, 31592, 40346, 41366, 49250, 56999; Australian Museum, [1] AMR12611).

The aim of this study was to collect basic ecological data for this species, which could then be used for a more intensive analysis of the species' life history. This information could be incorporated into conservation management plans in an attempt to safeguard this lizard's future survival.

STUDY SITE

On Brisbane City Council land in the Mt Crosby area, 30km W of Brisbane city, an area was chosen where a handful of specimens had been located (27°31'44"S 152°48'46"E). After two visits, it was apparent that *D. torquata* was present at four separate rocky sites. One main study site was chosen ('West') with two auxiliary sites as backup ('East' and 'Top'). 'West' was situated on the western side of a rocky ridge which is bisected by a dirt track. The site measured approximately 100m long, parallel to the ridge, and 30m wide down the western slope. It contained many small scattered loose rocks up to 700mm in diameter, plus some areas of exposed bedrock outcrops (Fig.1). The gradient averaged around 30° (range 0-50°). The other two sites were similar, 'East' being on the opposite side of the same ridge as 'West', 'Top' on the crest of a different ridge some 1500m to the south.

The area supports open, dry eucalypt woodland dominated by *Eucalyptus crebra*, *E. intermedius* and *E. maculata*, with an understorey of native and introduced plants and ground covers, particularly the introduced *Lantana montividensis* and the grasses *Cymbopogon refractus*, *Heteropogon contortus* and *Themeda triandra*. The substrate is covered in a 5-20mm layer of dry leaf litter. Soils are shallow and stony, and comprise poor quality lithosols on the ridges, with texture contrast soils on the slopes. Rocks are mostly mixed metamorphics of the Nerenleigh-Fernvale beds which include mudstones, chert, jasper, shale, basic volcanics and possibly laterites, although the latter are usually associated with higher altitudes (B. Powell, pers. comm.).

The average annual rainfall recorded at the Mt Crosby water treatment plant, 2km from the study site, over the last five years was 824mm (Brisbane City Council records). Most rainfall occurred between Dec. and March. Temperatures recorded over the last three years for Mt Crosby (5km from the study site), range from 1.0-41.5°C. (pers. obs.).

FIG. 1. *Delma torquata* habitat in 'West' study site, Mt Crosby.

METHODS

Initially, the study sites were visited once per month (June–Oct., 1993). Specimens were located by rock turning. For each capture site the following details were recorded; capture time and date; air temperature and humidity; under rock temperature; cloud cover; capture rock size; aspect and gradient; percentage rock and vegetation cover in a 2 × 2m quadrat around the capture rock; plant species in the same quadrat; distance and bearing from a set datum point.

Data concerning the mean rock diameter, percentage rock cover and percentage vegetation cover for the total site were obtained by running five transect lines (three of 50m and two of 30m) approximately 5m apart through the site. Data was recorded at each 2m interval along these lines using a 1 × 1m quadrat.

Each specimen was held overnight to facilitate the production and collection of faecal pellets. The following day the lizard was weighed and total length, snout-vent length and tail measurements were obtained by allowing the animal to crawl into a clear (5mm) plastic drinking straw. This could then be aligned next to a ruler providing measurements to $\pm$ 1.0mm.

Specimens were identified by utilising the throat marbling patterns, which appear to be unique between individuals. A permanent record was obtained by producing a photocopy of the ventral surface of each animal using the 200% enlargement setting.

The photocopy also allowed accurate counting of the paired ventral body scales of each specimen to access sexual dimorphism. These were counted as per Coulson (1990), starting at the first pair of enlarged ventral scales behind the smaller gular scales and ending at the pre-anal scale.

Monitoring the initial five captures after this process did not seem to produce any detrimental effects from the photocopying, and all lizards were subsequently released at the point of capture the following day.

The difficulty of relocating animals on previously searched sites suggested that rock turning may detrimentally alter the microhabitat. The loose substrate often collapsed into the depression vacated by the rock. This theory was reinforced by the ease of locating new specimens on

previously undisturbed sites nearby. Few specimens were located on disturbed sites for at least three months after the initial rock turning.

Consequently, four sets of five pitfall traps were installed in Nov., 1993. Traps were spaced at 1m intervals and comprised four litre plastic buckets dug into the ground flush to the soil surface. Aluminium insect mesh 5m long and 200mm high was used as a drift fence.

Two trap lines were set in a rocky area within the West site and two in a vegetated area with no rocks, some 20m from the nearest rocky area, to the south of East site. One trap line in each area was set parallel to the gradient, the other perpendicular. Traps were opened for 14 days and checked each morning and night, and then closed for six weeks by replacing the bucket's lid. This routine continued from Dec., 1993 until Dec., 1994. Any specimens captured in the traps were processed as previously described.

A final rock-turning survey was carried out at the end of the trapping program to ascertain if specimens had returned to the original area, subsequent to the initial disturbance.

Faecal pellets collected from captured specimens were soaked in 75% alcohol before being teased apart beneath a microscope for identification of material to the lowest possible taxonomic level.

A public awareness campaign was initiated in the southern part of the species' range in an attempt to enlist public assistance with finding new species localities in this area. Photographs highlighting the diagnostic characters were released in both widely distributed and localised newspaper publications (e.g., Brisbane Courier Mail; Karana Kronicle).

RESULTS

Thirty-nine specimens were captured and identified; 27 from West, 6 from East and 6 from Top. Two animals were recaptured once, one each from West and East, and one specimen from West was recaptured on two occasions (once beneath a different rock after 28 days and 3.5m from the original capture site, and again after 427 days another 18.2m from the second capture point). The two single recaptures were each located under the same rock as the original capture after periods of 33 and 28 days.

All hand captures during the study were found under rocks, with the exception of one specimen which was observed actively moving amongst low grasses at 08:45 hours on 8 Dec., 1992 at an air temperature of 26°C. Many specimens were extremely quick when disturbed beneath rocks and several evaded capture (one escaped into a termite burrow), suggesting the lizards were quite active before capture. All specimens were found on the surface of the soil usually with dorsal contact to the rock above, although one was located beneath a rock curled within a chamber of a subterranean termite nest.

Specimens were located beneath rocks during every season of the year. One was located for every 1.75 hours of searching regardless of season. This equates to around one lizard for every 150-200 rocks lifted.

The final rock-turning survey at the end of the pitfall trapping program produced a total of eight specimens of *D. torquata* over the entire West site during ten search hours. This equals the maximum number of specimens located in one day during previous visits, indicating the habitat had not been permanently damaged, although none of these eight were recaptures.

Only six captures were made in pitfall traps over the trapping period, four in Dec., one in Feb. and one in October. All were found in traps when they were checked in the afternoon, indicating activity and capture between 06:30-17:00 hours. Specimens of *D. torquata* were caught in both trap lines in the rocky area (four specimens) and in one trap line in the vegetated site (two specimens). A total of 1,960 trap days were carried out over the 13 month period to produce a success rate of 0.306 animals per 100 trap days.

Snout-vent length (SVL), tail length, weight and ventral scale count were recorded for each individual (Table 1). SVL's ranged from 31-70mm with a maximum total length of 196mm and a maximum weight of 1.78g. The smallest specimen found (SVL 30mm; mass 0.23gm) was located on the 3 Aug., 1993, while another captured on 4 Oct., 1994 measured 31mm SVL and weighed only 0.19g.

It was difficult to ascertain if tails were original or regrown, as the latter rarely exhibited an obvious demarcation point. Intact tails appeared to measure around 200% of the body length, with a maximum recorded at 214%. An arbitrary length of greater than 180% was chosen to indicate an intact tail in this study, which provides a figure of 66% of the population with regenerated tails.

Some indication of microhabitat use emerged. The diameter of rocks utilised by the lizards (mean 172cm) was significantly different to that of the whole study area where the mean was 126cm (t_{143}=2.48, P=0.014). Similarly, a significant

difference was found between the percentage vegetation cover for the study area (mean 42%) and the capture points (mean 31%), (t_{139}=2.25, P=0.026). Mean percentage rock cover for the study area (27%) was not significantly different to that for the capture points (33%), (t_{141}=1.25, P=0.21). Microhabitat temperatures varied greatly compared to ambient air temperatures, ranging from 8.8°C below ambient to 4.1°C above. The mean difference was 1.7°C below ambient for 34 captures.

As only 14 museum specimens were available, it was not possible to ascertain if ventral scale numbers are sex-linked in *D. torquata* without sacrificing living specimens. This did not seem justifiable for the present study. The degree of overlap of ventral scale counts between the sexes has inherent problems in accurately determining sex in many individuals. Handley (1994) showed that the only positive method of sexing *D. impar* Fischer, 1882 is to analyse X-rays of individual lizards to establish if a pair of post-cloacal bones are present or absent, as these only occur in males. X-ray facilities were not available during this study.

Contents of 14 faecal pellets collected from specimens at the Mt Crosby site were recorded (Table 2). Thirteen of 14 pellets contained insect or spider remains, mostly small cockroaches which were present in at least 8 of 14 pellets.

DISCUSSION

DISTRIBUTION AND HABITAT. The public awareness campaign produced no confirmed new locality records for *Delma torquata*. One tentative record was obtained from the Kalpowar area (24°42'S 151°19'E).

The previously described habitat of dry open eucalypt/*Acacia* woodland, with a sparse understorey of native grasses and small shrubs, usually associated with rocky outcrops on ridges (Wilson & Knowles, 1988) was confirmed in the present study. The requirement for rocky sites may be a biased perception caused by the problems of locating a small, agile lizard amongst vegetation. In the current study, specimens were located in pitfall traps up to 20m from the nearest rocks.

The holotype was found in black basalt soil six inches below the surface during posthole digging (Kluge, 1974). This observation has prompted previous authors to speculate that the species is a burrower (e.g., Cogger, 1992). However, Wilson & Knowles (1988) indicated otherwise and data from the current study show that this species is an active surface forager, as suggested by these authors.

POPULATION AND GROWTH. The small number of animals recaptured during this study and the apparent disturbance of animals by rock turning, violates the mark-recapture technique's assumption of constant trapability (Seber, 1973). Thus, it was not possible to accurately calculate an estimate of population size of *D. torquata* at the Mt Crosby study site. This problem is further exacerbated by sampling being only possible in the rocky areas of the site despite evidence from pitfall traps that other areas are utilised.

It is possible to surmise that the Mt Crosby population is relatively large, given the number of animals found and the small number of recaptures, with new captures still being made at the termination of the study; that the species is widespread because specimens were found at all rock outcrops examined and may be more widely distributed depending on their use of vegetated areas; that it is reproductively active, several juveniles being located during the study, their sizes being comparable to a hatchling (SVL 28mm) obtained from an egg (Kluge, 1974); and that it is apparently healthy, as all individuals appeared to be in good condition.

The data enable tentative prediction on the presence of size cohorts within the study population (Figs 2 & 3). A first winter cohort averages 32mm SVL and a mass of 0.28g (n=4). The second cohort is identifiable at a mean SVL of 52.6mm and 0.91g (n=14). A third cohort is less evident but seems to be present around 65mm SVL (n=5) and 1.41g (n=4).

The proportion of animals showing autotomy in this study is relatively high compared to two studies of *D. impar* (Coulson, 1990; Kutt,1992). Coulson (1990) found the incidence of autotomy varied greatly from site to site, ranging from zero (n = 13) at Rockbank to 57% at Derrimut. His analysis also showed that this difference was significant and postulated the cause as being differential levels of predation. Kutt's (1992) data indicated autotomy in 39% of the population. The 66% figure in the current study may be artificially high due to the difficulties of distinguishing whether specimens had original or regrown tails. It is possible that autotomy is related to the occurrence of intraspecific aggression rather than just predation. Agonistic interactions have been recorded in other *Delma* species, e.g., *D. inornata* Kluge, 1974 and *D. tincta* De Vis, 1888 (Sonneman, 1974, and pers. obs.).

HABITAT UTILISATION. The statistically significant results obtained concerning microhabitat utilisation suggest that *D. torquata* has a preference

TABLE 1. Body and tail measurements, mass and ventral scale counts of *D. torquata* specimens at Mt Crosby. * denotes recapture.

Date	Specimen No.	SVL (mm)	Tail (mm)	Tail/SVL (%)	Mass (gm)	Ventral Scale No.
3/6/93	T1	49	96	196	0.92	57
3/6/93	T2	31	63	203	0.32	61
3/6/93	T3	33	52	158	0.29	62
3/6/93	W4	61	114	187	1.41	60
3/6/93	W5	57	108	189	1.14	65
3/6/93	W6	45	87	193	0.66	58
3/6/93	W7	54	54	100	0.97	61
6/7/93	T8	61	51	100	0.68	62
6/7/93	W9	54	70	130	0.66	62
6/7/93	W6*	45	99	220	0.64	58
3/8/93	T10	61	100	214	1.04	60
3/8/93	133	33	59	173	0.28	61
3/8/93	W12	60	60	100	1.1	60
3/8/93	W13	70	103	147	1.27	60
3/8/93	W13	65	114	183	1.45	62
3/8/93	W15	56	36	60	0.71	62
3/8/93	W16	49	56	114	0.75	60
3/8/93	W17	36	61	170	0.23	60
7/9/93	W18	52	109	210	0.97	60
7/9/93	W19	49	45	92	0.65	60
7/9/93	E20	53	106	200	1.09	60
7/9/93	E21	66	88	133	1.51	63
7/9/93	E22	58	115	198	1.27	64
7/9/93	E23	62	85	137		62
5/10/93	W24	55	112	204	1.14	60
5/10/93	W25	49	69	141	0.77	58
5/10/93	E20*	53	108	204	1.17	60
5/10/93	W19*	49	47	96	0.73	60
12/12/93	E26	52	103	198	0.95	54
17/12/93	W27	54	114	186	1.22	62
20/12/93	W28	49	60	196	0.83	60
10/2/94	E29	45	41	91	0.46	61
15/2/94	W30	49	54	103	0.65	60
4/10/94	W31	31	47	152	0.19	58
5/12/94	W19*	52	76	146	0.76	60
4/4/95	W32	70	126	180	1.78	62
4/4/95	W33	52	60	162	0.8	60
4/4/95	W34	36	54	173	0.64	58
4/4/95	W35	49	87	178	0.64	62
4/4/95	W36	53	106	200	0.97	60
4/4/95	W37	47	69	147	0.74	61
4/4/95	W38	45	90	200	0.70	60
4/4/95	W39	50	85	170	0.65	59

for parts of its habitat. Slightly larger than average rocks are chosen, usually with less than average associated vegetation cover. This pattern may be related to the thermoregulation requirements of this lizard. These rocks may heat faster, with less shade from vegetation, while cooling down slower because of the greater mass to surface area ratio.

An inference from this study was the apparent sensitivity of *D. torquata* to habitat disturbance. It is uncertain if this adverse reaction was in response to habitat modification caused by rock turning, a stress reaction caused by the trauma of capture and processing, or a combination of the two.

Kutt (1992) captured 115 specimens of *D. impar*. Despite removing specimens from the site for processing and marking by heat-branding, one third of those were recaptures, indicating that pitfall trapping and handling do not preclude recapture. The specimens relocated in the present study at the disturbed site some 20 months after the last rock turning exercise does indicate that, if initial habitat alteration was a problem, it did not have a lasting detrimental effect.

Such sensitivity may explain the patchy distribution of the species. However, it does not provide answers as to why *D. torquata* is apparently still uncommon in some of these undisturbed sites, e.g., Crow's Nest NP where only one specimen has been recorded (Queensland Museum records). This may relate to insufficient surveying of these sites in the past, or their lack of optimal habitat.

The inefficiency of the pitfall traps is probably attributable to both the relatively low overall density of the species and to the problems of installing traps precisely enough to stop a 3-4mm diameter animal passing beneath the drift fence. This problem was further compounded by the steep gradient of the site, which was prone to erosion around the traps and fencelines.

Despite the apparent trap inefficiency, the trapping success rate in this study of 0.306 animals per 100 trap days is comparable to the figure of 0.304 animals obtained by Kutt (1992) working with *D. impar*. Captures in pitfall traps in both rocky and vegetated areas suggest the use of both habitats by *D. torquata*. It is still uncertain if specimens are commuting between these habitats, or if some lizards remain in each particular habitat for extended periods.

TABLE 2. Food items identified in faecal pellets from specimens of *D. torquata* captured at Mt Crosby.

Specimen No.	Date	Items Identified in Faecal Pellets
-	8/12/92	Family Blattellidae - fragments
-	8/12/92	Family Blattellidae - fragments
-	8/12/92	Family Blattellidae - fragments
T1	5/6/93	Plant matter - one piece
T2	5/6/93	Class Insecta - mandible ?coleopteran larvae
T3	5/6/93	Family Blattellidae - fragments
W9	7/7/93	Class Insecta - setae and cuticle
W19	7/9/93	Family Blattellidae - fragments
E36	7/9/93	Family Blattellidae - fragments
-	7/9/93	Class Insecta - leg segments
W22	17/12/93	Order Araneidae - fragments
W23	21/12/93	Family Blattellidae - fragments
-	10/2/94	Family Blattellidae - fragments
W24	15/2/94	Class Insecta - setae

Coulson (1990) indicates a similar possibility with *D. impar*, which were also initially only found under rocks. He states 'surveying reptiles by turning rocks has undoubtedly led to a biased perception of the significance of rocks as an essential habitat requirement, since the striped legless lizard is clearly not confined to rocky areas'. Coulson also points out that the presence of rocks often precludes the clearing and cultivation of native grasslands which, when other non-rocky areas are cleared, confines the species to these rocky sites, giving an unrealistic impression of the species' distribution.

The Mt Crosby study site has apparently never been cleared of vegetation and has only been affected by occasional natural fires (J. Hester, pers. comm.). Consequently, disturbance to the area has been kept to a minimum, which may explain the presence of relatively large numbers of *D. torquata*. Specimens still occur in disturbed areas around the site but the density appears much lower (pers. obs.).

ACTIVITY AND BEHAVIOUR. The pitfall trapping in this study also provided invaluable data concerning the activity patterns of the species (i.e., diurnally active), at least during certain times of the year. Pygopodids have often been regarded as being mostly nocturnal or crepuscular (Worrell, 1963; Kluge, 1976), including *Delma* species (Patchell & Shine, 1986). Personal observations of both *D. tincta* and *D. inornata* in captivity also indicate diurnal activity periods.

It is possible that activity cycles may be effected by the prevailing weather conditions. Jenkins & Bartell (1980) noted nocturnal and crepuscular activity for *D. impar* on hot days, whereas field research recorded diurnal activity (Coulson, 1990). Kutt (1992) found the day time to be the primary activity period for the species, with 17 of 26 captures made during the day. The time of capture of the remaining lizards could not be determined.

The thigmothermic behaviour of some *Delma* species, e.g., *D. impar* (Coulson, 1990), may give the impression of diurnal inactivity, as the animals are thermoregulating indirectly beneath rocks, etc. between periods of activity. This phenomenon appears to be present in *D. torquata,* as specimens disturbed beneath rocks were often extremely quick and evasive, perhaps indicating that they had been active previously and were attempting to re-adjust their body temperatures.

That *D. torquata* is susceptible to pitfall trapping suggests that the species is an active surface forager rather than a fossorial or burrowing species, as has been postulated in the past (Cogger, 1992; Ehmann, 1992). However, a burrowing habit does not necessarily preclude pitfall susceptibility as other such species, such as *Aprasia* and *Lerista,* are often caught in this fashion (G. Shea, pers. comm.). The finding of the type specimen underground (Kluge, 1974) does indicate some subterranean habits, perhaps associated with winter inactivity.

The two recaptures of specimens of *D. torquata* beneath the same rock after periods of around a month suggest the use of a specific home site. The second recapture of a specimen after 427 days only 18.2m from its previous location also hints at a potentially small home range. However, the lack of recaptures may also be interpreted as an indication of a highly mobile species. A similar dearth of recaptures was found in two separate studies of *D. impar* (Coulson, 1990; Moro, 1990).

The production of faecal pellets by several specimens captured in mid-winter (June and July), is indicative of feeding activity at this time, possibly inferring that the species does not obligatively enter a winter dormant phase. Pitfall captures only occurred from spring through to late summer, which may indicate at least a partial reduction of activity over winter. Other researchers have expressed difficulty in finding specimens of *D. torquata* after prolonged dry spells (S. Wilson, pers. comm.). That observation was not supported by the present study, specimens being found throughout winter and spring 1993, one of the driest on record for Brisbane (total annual rainfall at the Mt Crosby water treatment plant was only 582mm).

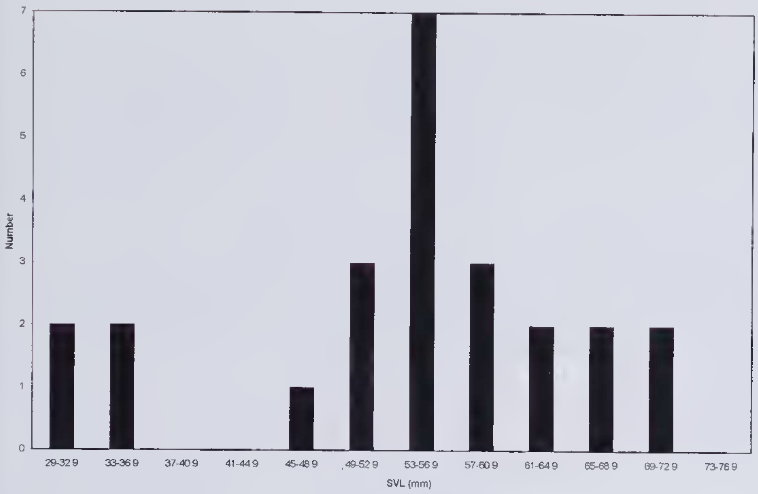

FIG. 2. Snout-vent lengths (mm) of all individual *D. torquata* captured during winter (June-Aug.) at Mt Crosby.

The indication that the microhabitat temperatures utilised by *D. torquata* were lower on average than the ambient air temperature is probably an artefact of the majority of the surveying being carried out between 07:00-12:00 hours, before direct solar radiation has had a major effect on heating the rocks concerned. That many lizards appeared very active when uncovered beneath rocks may suggest that they had already attained a preferred body temperature elsewhere and had subsequently moved beneath the rock.

DIET. Kutt (1992) found *D. impar* was more likely to defecate when cooled for 5-10 minutes in a refrigerator. This did not appear to be the case with *D. torquata*. The small number of pellets obtained does not provide a full picture of the diet of this species, but it does indicate that it is a insectivore with a possible preference for small cockroaches (Table 2).

These data agree with Patchell & Shine (1986). The three *Delma* species studied (D. *inornata, D. fraseri* Gray, 1831 and *D. nasuta* Kluge, 1974) were all active terrestrial foragers with generalised insectivorous habits, hunting mainly on the surface for active insects. Coulson's (1990) results from analysis of *D. impar* pellets were similar to that found in this study, in that the diet was generalised, but with a suggested preference towards one particular prey type — noctuid moth larvae.

STATUS. The apparent rarity of *D. torquata* may be a true indication of its status, not merely a reflection of its small size and secretive nature. Taking the Mt. Crosby site as an example of a natural population size and density, it appears that, where it does occur on undisturbed sites, the species is relatively abundant. These population characteristics seem to differ from some other species of *Delma*, e.g., *D. plebeia* De Vis, 1888 and *D. tincta*. Despite being common and widespread, these species can be difficult to locate (P. Couper and S. Wilson, pers. comm. and pers. obs.).

The scarcity of *D. torquata* in museum collections is further emphasised by the lack of public feedback received from the public awareness campaign initiated with this study. Approximately 30 telephone calls and letters were received following the press releases and of these only one was a potential sighting.

The indication that *D. torquata* is sensitive to even minimal habitat disturbance should be investigated more thoroughly. It is possible that land clearing and modification may be the most important factor dictating the current distribution

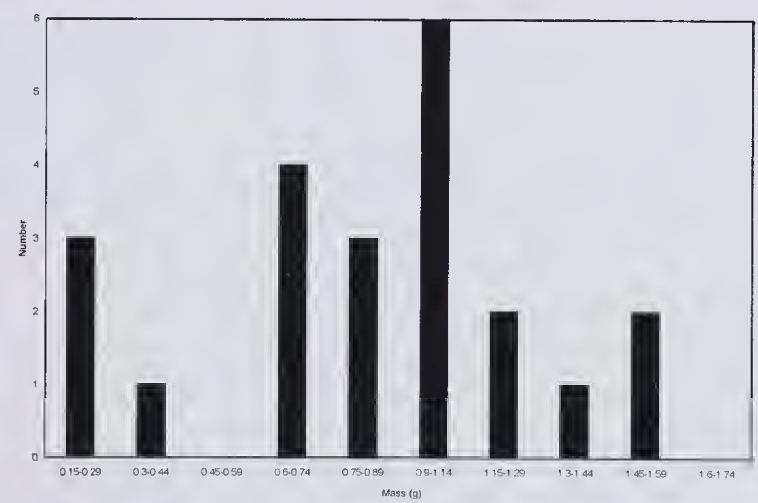

FIG. 3. Mass (g) of all individual *D. torquata* captured during winter (June-Aug.) at Mt Crosby.

of this species as seems to be the case with certain other pygopod species, e.g., *D. impar*, *Paradelma orientalis* (Günther, 1876) and *Pletholax gracilis* Cope, 1864 (Coulson, 1990; Ehmann, 1992).

A draft recovery plan for *D. torquata* has been produced by the Queensland Dept of Environment and Heritage (now Qld Dept of Environment) (C. Davidson pers. comm.), with an emphasis on surveying other potential areas of habitat and investigating the ecology of the species. The most important outcome of the current study in this respect is the discovery of a large, healthy population of a vulnerable species. The location of this population on council owned land means these animals should remain undisturbed and secure for the future.

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